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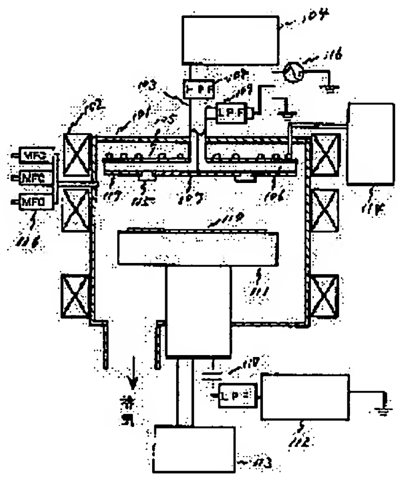
(54) PLASMA TREATING APPARATUS

(57)Abstract:
PROBLEM TO BE SOLVED: To generate a highly uniform magnetic field-having microwave plasma by feeding a an electromagnetic wave from a power source to a flat conductor board to radiate an electromagnetic wave for forming a plasma from the conductor board.
SOLUTION: An electromagnetic wave for forming a plasma is fed to a circular graphite conductor board 107 from a UHF band power source 104 through a coaxial line 103. The conductor board 107 is formed through a dielectric 106 on a ground potential conductor board 105 to form a microstrip line resonator owing to which a high frequency current flows at high efficiency on the circular conductor board to radiate an electromagnetic wave in air at the plasma side, thus forming a plasma of raw material gas by the mutual reaction of the electromagnetic wave radiated from the board 107 with a magnetic field caused by an air core coil 102.



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CLAIMS

[Claim(s)]
[Claim 1] Plasma-treatment equipment characterized by having a means to introduce reactant gas in a container and the aforementioned container, a means to exhaust the gas in the aforementioned container, a base for being prepared in the aforementioned container and installing a workpiece, and the plate that emits the electromagnetic wave for being prepared in the aforementioned container and generating a plasma.
[Claim 2] The aforementioned plate is plasma-treatment equipment according to claim 1 characterized by being formed so that the aforementioned plasma formed may be contacted.
[Claim 3] The plasma-treatment equipment characterized by to have a magnetic field formation means for being prepared in a means introduce reactant gas in a container and the aforementioned container, a means exhaust the gas in the aforementioned container, the base for being prepared in the aforementioned container and installing a workpiece, and the aforementioned container, being prepared in the plate which emits an electromagnetic wave in the position which meets the aforementioned workpiece, and the exterior of the aforementioned container, multiplying by the aforementioned electromagnetic wave, and forming a plasma.
[Claim 4] Plasma-treatment equipment according to claim 3 characterized by impressing the 300MHz or more 1st RF 1GHz or less to the plate which emits the aforementioned electromagnetic wave.
[Claim 5] Plasma-treatment equipment given in four characterized by making it superimpose on the 1st aforementioned RF, and impressing the 2nd RF.
[Claim 6] For the 1st aforementioned RF, the 2nd aforementioned RF is plasma-treatment equipment according to claim 5 characterized by being the frequency of a value different more than twice.
[Claim 7] The aforementioned plate is plasma-treatment equipment according to claim 3 characterized by preparing the matter which penetrates the aforementioned electromagnetic wave in the circumference section of a field which is prepared so that the plasma formed may be contacted, and contacts the aforementioned plasma of the aforementioned plate.
[Claim 8] The aforementioned matter is plasma-treatment equipment according to claim 7 characterized by consisting of an aluminum oxide, a quartz, a silicon nitride, a boron nitride, a steatite, or a zirconia.
[Claim 9] Plasma-treatment equipment according to claim 3 characterized by having the means which makes distance of the aforementioned base and the aforementioned plate adjustable.
[Claim 10] The aforementioned electromagnetic wave is plasma-treatment equipment according to claim 3 characterized by emanating as a circularly-polarized wave.
[Claim 11] A container, a means to introduce reactant gas in the aforementioned container, and a means to exhaust the gas in the aforementioned container, the base for installing the aforementioned container inside installation eclipse workpiece, and the position which is prepared in the aforementioned container and meets the aforementioned workpiece -- it is -- an electro-magnetic-radiation antenna, a dielectric, and grounding potential -- with the electrode which consists of a conductor
Plasma-treatment equipment characterized by having a means to impress the magnetic field for being prepared in the exterior of the aforementioned container, multiplying by the aforementioned electromagnetic wave, and forming a plasma.
[Claim 12] The aforementioned electrode is plasma-treatment equipment according to claim 11 characterized by being formed in the shape of a flat surface.
[Claim 13] The aforementioned electro-magnetic-radiation antenna is plasma-treatment equipment according to claim 11 characterized by being formed in the shape of a plate, and forming the slit in the aforementioned plate.
[Claim 14] The aforementioned electro-magnetic-radiation antenna is plasma-treatment equipment according to claim 11 which is a straight line-like and is characterized by there being two or more.
[Claim 15] It is the plasma-treatment equipment according to claim 11 which the aforementioned electro-magnetic-radiation antenna is a straight line-like, and three or more odd cross, and is formed and is characterized by the point which carries out a transposition describing above being in the position distant from the center of the aforementioned antenna.
[Claim 16] Plasma-treatment equipment according to claim 11 characterized by connecting the power of UHF band to the aforementioned electrode.
[Claim 17] It is the plasma-treatment equipment according to claim 11 characterized by for the 1st with a predetermined 300MHz or more value [value 1GHz or less] RF and the aforementioned predetermined value making the 2nd RF of the frequency of a value different more than twice superimpose, and impressing them at the aforementioned antenna.
[Claim 18] The aforementioned dielectric is plasma-treatment equipment according to claim 11 characterized by consisting of a quartz, an aluminum oxide, a silicon nitride, a boron nitride, a silicon carbide, a zirconia, a Pyrex glass, or Teflon.
[Claim 19] The aforementioned electro-magnetic-radiation antenna is plasma-treatment equipment according to claim 11

characterized by consisting of silicon, graphite, aluminum, and stainless either.
[Claim 20] A container and a means to adjust the pressure in the aforementioned container in predetermined 0.1Pa or more pressure of 3Pa or less, A means to impress the 1st RF to the base and the aforementioned base for being prepared in the aforementioned container and installing a workpiece, Plasma-treatment equipment characterized by having the plate which emits an electromagnetic wave in the position which is prepared in the aforementioned container and meets the aforementioned base, and a means to form the magnetic field for multiplying by the aforementioned electromagnetic wave and forming a plasma.
[Claim 21] A container, a means to introduce reactant gas in the aforementioned container, and a means to exhaust the gas in the aforementioned container, A means to impress a RF to the base and the aforementioned base for being prepared in the aforementioned container and installing a workpiece, Plasma-treatment equipment characterized by having the plate which is prepared in the aforementioned container, and is supplied from the position which is distant from a core in the electromagnetic wave for forming a plasma in the position which meets the aforementioned base, and emits the aforementioned electromagnetic wave.
[Claim 22] A container and a means to introduce the etching gas which consists of a compound containing a fluorine atom in the aforementioned container, A means to exhaust the gas in the aforementioned container, and the base for installing the wafer with which it was prepared in the aforementioned container and the silicon oxide was formed, The monotonous plate which consists of the graphite or silicon which emits the electromagnetic wave for forming a plasma in a means to impress a RF, and the position which meets the aforementioned base to the aforementioned base, Plasma-treatment equipment characterized by having a means to form the magnetic field for multiplying by the aforementioned electromagnetic wave and forming a plasma.
[Claim 23] A container, a means to introduce reactant gas in the aforementioned container, and a means to exhaust the gas in the aforementioned container, It is prepared in the base for installing the aforementioned container inside installation eclipse workpiece, and the aforementioned container. the position which meets the aforementioned workpiece -- it is -- grounding potential -- with the electrode which has the shape of a conductor, a dielectric, and alignment, and consists of an electro-magnetic-radiation antenna of less than **20% of the length of 1/4 wave of integral multiple of an electromagnetic wave Plasma-treatment equipment characterized by having a means to impress the magnetic field for being prepared in the exterior of the aforementioned container, multiplying by the aforementioned electromagnetic wave, and forming a plasma.
[Claim 24] A container, a means to introduce reactant gas in the aforementioned container, and a means to exhaust the gas in the aforementioned container, While the electromagnetic wave of UHF band is supplied to the base for being prepared in the aforementioned container and installing a workpiece, the plate which emits an electromagnetic wave in the position which is prepared in the aforementioned container and meets the aforementioned workpiece, and the aforementioned plate through a high pass filter Plasma-treatment equipment characterized by having a means to supply the electromagnetic wave of the frequency of a value different from the frequency of the aforementioned UHF band more than twice through a low pass filter, and a magnetic field formation means for being prepared in the exterior of the aforementioned container, multiplying by the aforementioned electromagnetic wave, and forming a plasma.
[Claim 25] The vacuum chamber with gas induction and the exhaust air section, and a processed sample installation means to install a processed sample in the aforementioned vacuum chamber, A magnetic field formation means to form a magnetic field in the manipulation side and perpendicular direction of the aforementioned processed sample, The microwave introduction means which becomes near where the grounding potential installed in the position which counters the aforementioned manipulation side is monotonous from a stripline, Plasma-treatment equipment characterized by plasma-izing the gas which has a microwave waveguide means to supply electric power to the plate and stripline of the aforementioned grounding potential in microwave power, and was introduced into the gaseous phase by the electromagnetic wave in the aforementioned vacuum chamber.
[Claim 26] Plasma-treatment equipment characterized by being any one kind of configuration of the configuration by the air cored coil by which the aforementioned magnetic field formation means controls a magnetic field distribution of a permanent magnet and the aforementioned permanent magnet, the configuration only by the air cored coil, and the configuration only by the permanent magnet in plasma-treatment equipment according to claim 25.
[Claim 27] Plasma-treatment equipment characterized by the aforementioned permanent magnet being the cylindrical shape whose thickness a diameter is 70 to 150% of the domain of the diameter of a processed sample, and is 10 to 100% of the domain of the aforementioned diameter in plasma-treatment equipment according to claim 26.
[Claim 28] Plasma-treatment equipment characterized by for the aforementioned permanent magnet approaching, and arranging and constituting it in two or more small magnets in plasma-treatment equipment according to claim 26 or 27.
[Claim 29] Plasma-treatment equipment characterized by constituting a part of aforementioned permanent magnet [at least] perpendicularly possible [a move] to the manipulation flat surface of the aforementioned processed sample in plasma-treatment equipment according to claim 27 or 28.
[Claim 30] Plasma-treatment equipment characterized by having arranged the aforementioned stripline focusing on the feeding point at the radial in the claim 25 or the plasma-treatment equipment of any one publication of 29.
[Claim 31] Plasma-treatment equipment which the aforementioned stripline is a straight line-like, and is characterized by having arranged two or more in parallel in the claim 25 or the plasma-treatment equipment of any one publication of 29.
[Claim 32] In the plasma-treatment equipment of any one publication the claim 25 or given in 29 Two or more antennas which consist of an aforementioned stripline are arranged at the periphery in the aforementioned vacuum chamber. The feeding point of the aforementioned electromagnetic wave to the aforementioned stripline is considered as positions other than the position used as the voltage of the aforementioned electromagnetic wave on the aforementioned antenna, and the wave node of a current distribution. the conductor which introduces the electromagnetic wave furthermore arranged by being parallel to the manipulation side of the aforementioned vacuum chamber center section to a radial and the aforementioned processed sample, and approaching the aforementioned feeding point at the plate of the aforementioned grounding potential -- the plasma-treatment equipment

characterized by having a track

[Claim 33] Plasma-treatment equipment characterized by supplying the electromagnetic wave from which a phase is different at each aforementioned antenna in plasma-treatment equipment according to claim 32.

[Claim 34] The antenna which consists of an aforementioned stripline in the plasma-treatment equipment of any one publication the claim 25 or given in 29 is plasma-treatment equipment characterized by arranging to a radial in positions other than the position of three or more which is arranged odd and serves as the voltage of the electromagnetic wave on the aforementioned antenna, and the wave node of a current distribution in the aforementioned feeding point, using the feeding point of the aforementioned electromagnetic wave to the aforementioned antenna as an intersection.

[Claim 35] Plasma-treatment equipment characterized by covering the aforementioned stripline with quartz glass in the claim 25 or the plasma-treatment equipment of any one publication of 34.

[Claim 36] Plasma-treatment equipment characterized by the length of the aforementioned stripline being **20% of the domain of 1/4 wave of integral multiple of the electromagnetic wave in the inside of the medium by which the aforementioned stripline is installed in the claim 25 or the plasma-treatment equipment of any one publication of 35.

[Claim 37] the claim 25 or the plasma-treatment equipment of any one publication of 35 -- setting -- the near feeding point to the aforementioned stripline -- between the aforementioned stripline and the aforementioned processed sample installation meanses -- the shape of a disk -- the plasma-treatment equipment characterized by installing a conductor

[Claim 38] Plasma-treatment equipment characterized by connecting the aforementioned stripline with the aforementioned vacuum chamber through a quartz aperture in the claim 25 or the plasma-treatment equipment of any one publication of 35.

[Claim 39] the grounding potential with opening of 100 to 500% of width of face to the width of face of the antenna which consists of a stripline in plasma-treatment equipment according to claim 38 at the plasma side of the aforementioned quartz aperture -- the grounding potential with [install a conductor so that the aforementioned opening may meet the aforementioned stripline, and] the aforementioned opening as the plate of the aforementioned grounding potential -- the plasma-treatment equipment characterized by arranging a stripline in the interval of a conductor and constituting a microwave feed zone

[Claim 40] the grounding potential with the plate or opening according to claim 36 of grounding potential according to claim 25 -- a conductor or the shape of a disk according to claim 37 -- the plasma-treatment equipment characterized by using a conductor as the grounding electrode of a plasma

[Claim 41] Plasma-treatment equipment characterized by the aforementioned manipulation sample installation means having a RF electric-field impression means and a temperature-control means in the plasma-treatment equipment of any one publication the claim 25 or given in 40.

[Claim 42] Plasma-treatment equipment whose frequency of the electromagnetic wave supplied to the aforementioned stripline for plasma formation is characterized by being for 2.5GHz from 400MHz in the plasma-treatment equipment of any one publication the claim 25 or given in 41.

[Translation done.]

* NOTICES *

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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the plasma surface treatment equipment used for the dry etching process which processes the front face of a semiconductor material according to the physics or the chemical reaction of the manufacturing installation of a semiconductor device, and the grain which plasma-ized the material gas in a gaseous phase especially, and was activated.
[0002]
[Description of the Prior Art] As equipment of plasma use used in the manufacture stroke of the conventional semiconductor device, the Hitachi criticism, 76, No.7, (1994), and the owner magnetic field microwave etching system currently described by 55-58 pages have been used about etching. The owner magnetic field microwave etching system has plasma-ized the gas by the electromagnetic wave of the microwave field introduced in a vacuum housing through the magnetic field and microwave circuit which were generated by the air cored coil. A sample is conventionally processible at highly precise and a high speed from this plasma density with equipment expensive at low gas ** being obtained. Furthermore, for example, an applied physics letter (Appl.Phys.Lett.), 62, No.13 (1993), and the owner magnetic field microwave etching system that uses the part magnetic field by the permanent magnet for 1469-1471 pages are reported. with this equipment, since a magnetic field is formed with a permanent magnet, an equipment cost and power consumption can be markedly boiled conventionally [above-mentioned] compared with equipment, and can be made low Moreover, a 1GHz RF generating a plasma to JP,3-122294,A from 100MHz, and etching into it efficiently using a mirror magnetic field is indicated. Furthermore, to it, to JP,6-224155,A, a 100 to 500MHz RF is applied from the antenna of the pectinate, a plasma is generated, and forming a uniform plasma within the diameter-ized chamber of the macrostomia is indicated.
[0003] Moreover, ****** parallel monotonous type (henceforth a "****** type") equipment is especially put in practical use as an object for a silicon-oxide manipulation. A ****** type impresses a MHz [more than 10 to some dozens of] RF to the parallel plate of 2cm [1cm to] spacing, and forms the plasma. As for ****** type equipment, a material gas pressure is used in some dozens mTorr field. a ****** type -- ****** -- a stable oxide-film etching property has the characteristic feature acquired over a long period of time
[0004] Moreover, applying an about 300MHz RF to JP,7-307200,A from the antenna of the radial which has 1/4 merit of introductory wavelength is indicated.
[0005]
[Problem(s) to be Solved by the Invention] However, in the owner magnetic field microwave etching system which uses the part magnetic field by the above-mentioned permanent magnet, since [which is depended on a small permanent magnet] more than one are used, it is bad and installs in the position which separated the processed sample from the plasma production field, and the homogeneity of the plasma in the field in which the magnetic field field plasma is mainly generated equalizes a plasma by diffusion, and uses it. For this reason, in a processed sample position, there is a problem that sufficient plasma density is not obtained and sufficient working speed is not obtained.
[0006] Moreover, with the efficient consumer response type equipment like JP,3-122294,A or JP,6-224155,A, since the source of an owner magnetic field microwave plasma introduces an electromagnetic wave from the position which meets a sample, a sample confrontation position can lay only an insulator. By this, when a RF bias was impressed to a processed sample, a required grounding electrode could not be installed in the position which meets the processed sample which is an ideal position, but there was also a problem that the ununiformity of a bias arose.
[0007] Furthermore, since operating gas pressure is comparatively high, below on 0.2 micron level, the directivity of the active species in a plasma becomes uneven, and since a plasma density is low, especially a ****** type has a problem in the point that an etch rate is low, bad [micro-processing nature]. On the other hand, the maceration of material gas progresses too much, the chemical reaction on a gaseous phase or the front face of a wafer seldom controls the equipments using the so-called source of a high-density plasma, such as efficient consumer response type and an inductive-coupling type, and it has the problem from which a stable etching property is hard to be acquired. Especially, in etching of a silicon oxide, since [which obtains a selection ratio by making etching and a deposition compete] a process, if the controllability of a reaction is bad, it will have serious influence for the manipulation (quantity aspect manipulation) performance of a selection ratio or a deep hole.
[0008] Moreover, although the homogeneity of a plasma will go up by the antenna of the pectinate like a JP,6-224155,A publication, or the antenna of a radial like a JP,7-307200,A publication if it compares when not using an antenna, high homogeneity still cannot be acquired.
[0009] the purpose of this invention -- power consumption -- few -- case the manipulation area of a processed sample is large --

quantity -- a uniform owner magnetic field microwave plasma is generated, and it excels in micro-processing nature, a high selection ratio and a high aspect manipulation are possible, and it is in offering the plasma-treatment equipment which can perform high-speed manipulation processing

[0010] Other purposes of this invention can install a grounding electrode in the position which meets a processed sample in efficient consumer response type equipment, and are to offer the plasma-treatment equipment which can perform equalization of a RF bias easily.

[0011]

[Means for Solving the Problem] the 1st above-mentioned purpose -- an electromagnetic wave -- the conductor of the shape of power to a flat surface -- a plate -- supplying -- the conductor -- it is attained by emitting the electromagnetic wave for forming a plasma from a plate Since an electromagnetic wave can be uniformly supplied in the orientation of a wafer by supplying an electromagnetic wave from a flat surface, the high homogeneity of a plasma will be acquired.

[0012] Furthermore, when a frequency supplies the electromagnetic wave of 1GHz UHF band from 300MHz, since wavelength is 30cm to 80cm, the 300MHz to 1GHz electromagnetic wave is of the same grade as the diameter of a vacuum housing of the 8 to about 16 inches diameter plasma-treatment equipment of the macrostomia, and is suitable for processing the wafer of the diameter of the macrostomia.

[0013] Moreover, when gas ** of etching gas is made into the domain of 0.11 to 3Pa, while the directivity of the active species which contributes to etching is ready, an etch rate becomes large and it is effective in excelling especially in micro-processing nature. When gas ** was made small too much, while a plasma density becomes small and a desired etch rate was not obtained, when gas ** is enlarged too much, directivity will stop becoming complete.

[0014] furthermore, a conductor -- the active species which a plate and etching gas are made to react and is needed for etching is formed -- as -- a conductor -- a desired active species can be obtained efficiently and it becomes easy to control a reaction by choosing the material and etching gas of a plate If the electric field of the frequency different from especially the electric field and the frequency of UHF band of the frequency of UHF band are superimposed and supplied to this electric conduction plate, such a bias becomes large at an electric conduction plate, and the reactivity of an electric conduction plate and reactant gas will become high, and will become possible [generating more active speciess of the request which contributes to an etching reaction].

[0015] moreover, the position where the 2nd above-mentioned purpose meets the sample in a reaction container -- an electro-magnetic-radiation antenna, a dielectric, and grounding potential -- it is attained by preparing the electrode which consists of a conductor Thus, since grounding potential can be prepared in the position which meets a sample, to a wafer, uniformly, a bias becomes such a thing and can equalize the etch rate in the core and edge of a wafer as a result. In addition, it is not necessary to necessarily make the above structures, then an antenna configuration into the shape of a flat surface, and the antenna of the conventional radial or the pectinate may be used.

[0016]

[Embodiments of the Invention]

(Example 1) the position which plasma-izes the material gas introduced into the gaseous phase according to the synergism of the electromagnetic wave of UHF band, and a magnetic field in this example, and meets a processed sample further -- a conductor -- a plate -- installing -- a conductor -- it considered as the structure which can control the activity grain which acts on a processed sample front face by the reaction with the plasma on a plate this conductor -- the function to impress the RF electric field to a plate further, and to make the aforementioned reaction perform efficiently can also be added this conductor -- a plate has a function as a counterelectrode of the RF electric field impressed to the radiation function and the processed sample of UHF band electromagnetic wave

[0017] This equipment is shown in drawing 1 . In the example of drawing 1 , the air cored coil 102 is arranged around the vacuum housing 101. Into the vacuum housing 101, the 500MHz electromagnetic wave is supplied by the coaxial track 103 by the source 104 of UHF electrification. The feed-zone detail drawing of UHF band electromagnetic wave is shown in drawing 2 . the electromagnetic wave introduced into the vacuum -- the conductor of grounding potential -- the round conductor plate 107 made from graphite which approached the plate 105 through the dielectric 106 which consists of a quartz is supplied The diameter of the round conductor plate 107 is made into the path from which the resonance mode of an electromagnetic wave is obtained on a round conductor plate. In this example, the round conductor plate 107 which is the diameter of about 15cm which can excite the TM11 mode was used. in addition, the TM11 mode -- the propagation gestalt of an electromagnetic wave -- it is -- this example -- a round conductor plate and grounding potential -- a conductor -- it is the standing wave distribution of most a low degree of the electromagnetic wave formed in between, and becomes a basic mode electric supply of UHF band electromagnetic wave to the round conductor plate 107 top is given so that a center may be avoided to obtain, as shown in drawing 2 Since the wave node of the standing wave of the electromagnetic wave voltage on a round conductor plate is equivalent to the position when electric power is supplied in UHF band electromagnetic wave in the center position of the round conductor plate 107, an electromagnetic wave cannot be efficiently emitted to space. Therefore, with the configuration of this example shown in drawing 2 , electric power is supplied to the position which carried out eccentricity in UHF band electromagnetic wave, and high electro-magnetic-radiation luminous efficacy obtains. As shown in drawing 1 , the low pass filter 109 which passes the high pass filter 108 which passes 100MHz or more of the outputs of the source 104 of UHF electrification, and 20MHz or less is connected. The end of a low pass filter 109 is connected to grounding or 300kHz RF generator 116. Moreover, 800kHz RF generator 112 is connected to the sample base 111 in which the processed sample 110 is installed. Moreover, it is set up so that the temperature-control means 113 may be installed in the sample base 111 and the processed sample 110 may always become fixed temperature. In this example, it is set up so that the temperature of the processed sample 110 may always become 60 degrees about Centigrade. the temperature of the round conductor plate 107 which emits an electromagnetic wave -- the conductor of grounding potential -- it is controlled by the temperature-control means 114 installed in the plate 105 It is covered in the ring 115

formed in the periphery section of the round conductor plate 107 by the oxidization aluminum (alumina). The electric field of UHF band electromagnetic wave are the positions over which it is distributed most strongly, the periphery section of the round conductor plate 107 prevents local plasma formation in the periphery section of the round conductor plate 107 with this ring 115, and the uniform plasma formation of it is attained. Although the quality of the material of a ring 115 was used as the alumina in this example, since there should be just few degrees which generate the impurity which is the quality of the material which can penetrate an electromagnetic wave, and poses a problem in the case of a manipulation of a semiconductor device, even if the aforementioned ring 115 uses a quartz, a silicon nitride, a boron nitride, a steatite, and a zirconia for others, it has the same effect. Material gas is introduced by the material gas introduction means 116 into the vacuum housing 101. In this example, 15mTorr introduction was carried out from five into the vacuum housing 101 using the material gas which mixed C4F8 and the argon to material gas. The above basic configuration performs etching of a silicon oxide in this example.

[0018] Next, an operation of the example of drawing 1 is explained. The electromagnetic wave for forming a plasma is supplied to the round conductor plate 107 made from graphite through a coaxial track 103 from the source 104 of UHF electrification. the round conductor plate 107 -- the conductor of grounding potential -- a microstrip line resonator consists of forming in a plate 105 through a dielectric 106 The current of a RF flows efficient to a round conductor plate surface according to the resonator structure of the round conductor plate 107, and an electromagnetic wave is emitted to the space by the side of a plasma. Thus, material gas is plasma-ized by the interaction with the magnetic field by the electromagnetic wave and the air cored coil 102 which were emitted from the round conductor plate 107. It is enabled to form a plasma efficient by setting the conditions of a electron cyclotron resonance as a **** size (100 to 250 gauss) for the magnetic field in a vacuum housing 101 to a 500MHz electromagnetic wave at this time.

[0019] If a plasma is formed by the electromagnetic wave of UHF band using a electron cyclotron resonance phenomenon as shown in drawing 3 , compared with the 2.45GHz microwave band conventionally used with the electron cyclotron resonance type plasma, electron density can be made high and the status that electron temperature is low can be realized. in order that the maceration of the material gas in a plasma may be dependent on electron temperature -- low -- a plasma [****] can be formed Moreover, since the formation device of a plasma uses the electron cyclotron resonance, the high-density plasma formation of it is attained like the electron cyclotron resonance type using the conventional microwave band at low gas **. The problem of a controllability degradation of the etching reaction by the high maceration which had become the problem in the source of a high-density plasma conventionally by this is solvable.

[0020] Next, it describes about the plasma production luminous efficacy in efficient consumer response plasma over an electromagnetic wave frequency. The generation luminous efficacy of a plasma is decided by the balance of the generation rate of an electron and the charged particle of ion, and a loss speed. First, it describes about the generation rate of a charged particle. The plasma heating device of efficient consumer response plasma in the gas pressure 1 - number 10mTorr becomes main [two kinds by the collision heating device of a thing and an electron depended on efficient consumer response phenomenon]. The heating luminous efficacy by efficient consumer response is decided by the size of efficient consumer response field, and such high heating luminous efficacy is acquired that it is large. The size of efficient consumer response field is mostly in inverse proportion to the size and electromagnetic wave frequency of magnetic field inclination. Therefore, the heating luminous efficacy by efficient consumer response phenomenon serves as the inclination that the one where an electromagnetic wave frequency is lower is high. Moreover, it depends for the heating luminous efficacy by the electronic collision heating device on the electronic imitation nature to the oscillating electric field of an electromagnetic wave. it may be used by the conventional efficient consumer response, and an electron cannot follow vibration of the electromagnetic wave electric field enough according to electronic inertia, but a microwave field (for example, 2.45GHz) becomes low as heating luminous efficacy Therefore, the luminous efficacy in which the one where a frequency is lower is high is acquired also for the heating luminous efficacy by collision heating. However, since the energy loss by collision of electrons, such as the grain within a gaseous phase and a vacuum-housing wall, becomes large and heating luminous efficacy becomes low when an electromagnetic wave frequency is too low, the luminous efficacy by collision heating has most efficient UHF band in this invention. Next, it describes about the loss speed of a charged particle. When an electromagnetic wave frequency is low, there are few magnetic fields required for efficient consumer response, and they end. However, a magnetic field confines a plasma in space, and a loss speed rashly in a low magnetic field, and it becomes the factor which lowers the generation luminous efficacy of a plasma. [have / the work to which a loss is reduced] Therefore, if it considers synthetically in order to be rash also in the loss speed of a charged particle although the generation rate was rash and it described that it was effective in plasma production luminous efficacy (however, it will become the opposite effect in a collision heating device if too low) when an electromagnetic wave frequency was low, plasma production luminous efficacy will become low. It is drawing 16 which collected this phenomenon as a relation between efficient consumer response plasma production luminous efficacy and an electromagnetic wave frequency. When an electromagnetic wave frequency is low, the plasma by the increase and the magnetic field intensity of electronic energy loss in a collision heating device being small shuts up, plasma production luminous efficacy becomes low by the decrement in an effect, and when an electromagnetic wave frequency is high, plasma production luminous efficacy falls from a decrement of efficient consumer response field, and a fall of the flattery nature to electromagnetic wave electric-field vibration of an electron. therefore, as low gas pressure also shows efficient consumer response method in which good plasma formation is possible to drawing 16 , 300 to 1000MHz UHF band is the most expensive -- plasma production ****** is carried out With UHF band, since a required magnetic field intensity is low and high plasma production luminous efficacy is not only acquired, but it ends from the conventional microwave band, laborsaving can attain sharply the magnetic field formation which needed large power conventionally. Moreover, the plasma formation of saying that plasma production luminous efficacy is high which shows that a high plasma density is maintainable with a low electron temperature, and suppressed the maceration of material gas is attained.

[0021] Next, the reaction controlling method is explained. forming a electron cyclotron resonance plasma by the electromagnetic

wave of UHF band from a previous explanation -- low -- the plasma [****] was realizable However, the reaction kind control ideal for silicon-oxide etching is difficult only by low dissociation nature. For example, when forming a plasma using chlorofluocarbon system gas (this example C4 F 8), reaction kinds useful to silicon-oxide etching are CF and CF2. low -- though many these reactions kinds are able to be relatively formed by the plasma [****], a fluorine atom will be generated so much A fluorine atom is the key factor of the selection-ratio fall to the opposite silicon at the time of silicon-oxide etching, a resist, and a nitride, and is grain which is not not much desirable as etching conditions. Then, in this invention, the round conductor plate 107 which performs electro magnetic radiation was formed by graphite, and it considered as the structure of making a graphite front face and a fluorine atom reacting. The knife of the detrimental fluorine atomic weight can be carried out, and you can generate effective CF and CF2, and can make it reflected in etching of a processed sample by making a fluorine react on a graphite front face. By making into graphite the round conductor plate 107 which meets especially the processed sample 110, the reaction on the front face of graphite can be most effectively reflected on the processed sample 110. By adjusting the magnetic field by the air cored coil 102, after the processed sample 110 and the round conductor plate 107 have approached by forming a electron cyclotron resonance magnetic field between the processed sample 110 and the round conductor plate 107 (status which can reflect the reaction of round conductor plate 107 front face in the reaction of a processed sample front face efficient), uniform plasma formation is possible. In this example, the processed sample 110 and distance between the round conductor plates 107 are made into the structure in which adjustable is possible between 2cm and 30cm, and it has the structure where both reflection luminous efficacy to the processed sample front face of the homogeneity of a plasma and the reaction in round conductor plate 107 front face can be adjusted to an compatible position. the temperature of the round conductor plate 107 which emits an electromagnetic wave -- the conductor of grounding potential -- it is controlled by the temperature-control means 114 installed in the plate 105, and is maintained at temperature always fixed This has achieved stabilization of the reaction on the round conductor plate 107. Moreover, in this example, the round conductor plate 107 is connected to grounding through the low pass filter 109. To the 800kHz RF which this impresses to the sample base 111, the round conductor plate 107 acts as a grounding electrode, and equalization of the bias impressed to a processed sample is also attained. In this example, since there is the consumption effect of a fluorine even if it uses silicon, although the round conductor plate 107 was made into graphite, there is same reaction control function. Although the material gas which mixed C4F8 in order to etch a silicon oxide in this example, and mixed oxygen at the base was used, even if it uses CF4, C2F6, CHF3, CH2F2, and CH3F for the main gas as others, it cannot be overemphasized that there is same effect. Moreover, even if it uses the hydrogen, CO, and rare gas other than oxygen also as addition gas, there is a same and effective effect.

[0022] In this example, although the 500MHz electromagnetic wave was used for the electromagnetic wave of UHF band, even if it uses a 1GHz electromagnetic wave from 300MHz, there is effect same with being shown in drawing 3 . Moreover, wavelength is about 30cm to 80cm, and compared with the case where especially 8 inches or more are of the same grade as the diameter of a vacuum housing of the diameter plasma-treatment equipment of the macrostomia more than a 12 inch wafer, and are hard to generate the standing wave of the higher mode accompanied by the instability and heterogeneity of a plasma in a vacuum housing, and a magnetic field intensity required for plasma formation also uses the conventional microwave, a 300MHz to 1GHz electromagnetic wave is small, and ends. Therefore, if plasma formation is performed by UHF band electromagnetic wave of a frequency range, plasma-treatment equipment suitable for the manipulation of the diameter wafer of the macrostomia can be realized by the low cost. Therefore, the frequency range of UHF band electromagnetic wave used for the plasma formation in this invention is set to 1GHz from 300MHz.

[0023] Although the RF electric field impressed to a processed sample were set to 800kHz in this example, there is an effect with the same said of 20MHz RF electric-field impression from 100kHz.

[0024] Although the dielectric 106 which installs the round conductor plate 107 was used as the quartz in this example, even if it uses the oxidization aluminum, a silicon nitride, a boron nitride, silicon carbide, a zirconia, a Pyrex glass, and Teflon for others, there is same effect.

[0025] Although this example described the case where etching of a silicon oxide was performed, the round conductor plate 107 is made into silicon, graphite, aluminum, and any one stainless kind, and it can apply to etching of aluminum, silicon, and a tungsten by using chlorine-based gas for material gas further.

[0026] Although the reaction on the round conductor plate 107 arranged in the position which meets a sample performed the activity grain kind control in this example, the same activity grain kind control is possible also for forming 50% or more of the vacuum-housing wall with which a plasma touches with the same quality of the material. At this time, a highly precise activity grain kind control is attained by installing a RF electric-field impression means and a temperature-control means in a wall. The domain of 20MHz accelerates ion efficiently from the same 100kHz as the RF electric field impressed to a processed sample, and the RF electric field impressed to a wall can promote a reaction. However, if a frequency is not made more than twice as the RF electric field impressed to a processed sample, the power with a difficult and mutual design of a VCF will be affected. Therefore, it is good to, make into 800kHz the RF electric field impressed to a processed sample for example, and to make into 300kHz the RF electric field impressed to a wall. This is the same also in RF generator 116 impressed to the aforementioned round conductor plate 107 simultaneously with UHF band electromagnetic wave, and it is required to make more than twice to the frequency of the RF electric field which the frequency of RF generator 116 is also 20MHz from 100kHz, and are impressed to a processed sample.

[0027] There is effect same also as a configuration which forms the slit 120 which is shown in the round conductor plate 107 in this example in drawing 4 , and forms a plasma using the electromagnetic wave emitted from a slit, and it is enabled to realize more uniform plasma formation by optimizing the size or number of slits further.

[0028] (Example 2) The plasma-treatment equipment of an example 2 is shown in drawing 5 . In drawing 5 , it is the example characterized by making into a circularly-polarized wave efficient to formation of a plasma the electromagnetic wave which

devises electromagnetic wave supply to the round conductor plate used as the electro-magnetic-radiation antenna in the example of drawing 1, and is emitted from a round conductor plate. Since a rough configuration is the same as that of the example of drawing 1, it describes an explanation only about a different electromagnetic wave feed zone.
[0029] Into the vacuum housing 201, the 500MHz electromagnetic wave is supplied by the coaxial track 202 by the source 205 of UHF electrification. the electromagnetic wave introduced into the vacuum -- the conductor of grounding potential -- the round conductor plate 208 made from graphite formed through the dielectric 207 which becomes a plate 206 from a quartz is supplied Electromagnetic wave supply to the round conductor plate 208 divides the electromagnetic wave from a coaxial track 202 into two lines, as shown in drawing 6, and it makes one side a track long 1/4 wave, and supplies it to two points of the round conductor plate 208 (it is drawing 6 for details). Face ****** can do the phase of the electromagnetic wave which supplies electric power to the round conductor plate 208 by shifting the length of the electrical transmission way 203 of the electromagnetic wave divided into two quadrant wave motion length 90 degrees. The electromagnetic wave from which the phase shifted 90 degrees is compounded with round conductor tabular, forms the rotation electric field, turns into a circularly-polarized wave, and is emitted to space from the round conductor plate 208. The diameter of the round conductor plate 208 is made into the path from which the resonance mode of an electromagnetic wave is obtained on a round conductor plate like the example of drawing 1. In this example, the round conductor plate which is the diameter of about 15cm same with the example of drawing 1 which can excite the TM11 mode was used.
[0030] In addition, about an operation and detail of this example, it is the same as that of the example of drawing 1.
[0031] (Example 3) The example 3 of this invention is shown in view 7. The radiation technique of UHF band electromagnetic wave for this example mainly forming a plasma differs from the example of the previous drawing 1. In the example of drawing 7, the air cored coil 302 is arranged around the vacuum housing 301 like the example of drawing 1. Into the vacuum housing 301, the 500MHz electromagnetic wave is supplied by the coaxial track 303 by the source 304 of UHF electrification. the electromagnetic wave introduced into the vacuum -- the conductor of grounding potential -- the electro-magnetic-radiation antenna 308 arranged in the shape of a periphery by the microstrip line 307 formed through the dielectric 306 which becomes a plate 305 from a quartz is supplied Moreover, the round conductor plate made from graphite 309 of grounding potential is installed in a center section. The detail of the electro-magnetic-radiation antenna 308 is shown in drawing 8. the outside of a coaxial track 303 -- a conductor -- the conductor of grounding potential -- it connects with a plate 305 and a core wire is connected to each electro-magnetic-radiation antenna 308 which was quadrisected and has been arranged in the shape of a periphery Electro-magnetic-radiation antenna length is made from 1/2 wave (wavelength within a dielectric 306) of integral multiple. In this example, about 15cm thing which is 1/2 wave of length was used. The track connected to each electro-magnetic-radiation antenna 308 from a coaxial track 303 changes 1/4 wave of track length at a time, respectively, and is connected. Electromagnetic wave supply at each electro-magnetic-radiation antenna 308 can shift a phase by a unit of 90 degrees by this, it can supply, and the reflective electromagnetic wave from each electro-magnetic-radiation antenna 308 is offset by the feeding point 309. Moreover, the synthetic electric field of the electromagnetic wave emitted from each electro-magnetic-radiation antenna 308 serve as a rotation electric-field place, and the plasma formation luminous efficacy by the interaction with a magnetic field increases.
[0032] In this example, the round conductor plate made from graphite 309 acts as a grounding electrode of the RF electric field impressed to the reaction control function and the processed sample 310 in an example of drawing 1. The device as the reaction controlling method and a grounding electrode is the same as the example of the previous drawing 1. However, in order that the round conductor plate made from graphite 309 in this example may not have the need of performing electro magnetic radiation, it is easy to make a control function, a gas supply device, etc. of temperature directly to the aforementioned round conductor plate, and has the advantage whose reaction stability on the aforementioned round conductor plate improves. Moreover, like the example of drawing 1, even if it forms the round conductor plate made from graphite 309 with silicon, the same reaction control is possible. Furthermore, it is also possible to impress the 20MHz RF electric field to the round conductor plate made from graphite 309 from 100kHz, and to control the reacting weight and reaction mechanism on a front face by the bias like the example of drawing 1.
[0033] Although the reaction on the round conductor plate made from graphite 309 arranged in the position which meets a sample performed the activity grain kind control in this example, the same activity grain kind control is possible also for forming 50% or more of the vacuum-housing wall with which a plasma touches with the same quality of the material. At this time, a highly precise activity grain kind control is attained by installing a bias impression means and a temperature-control means in the aforementioned wall.
[0034] in addition, a stripline -- the conductor of grounding potential -- a plate top -- a dielectric film and a it top -- a conductor -- a track is formed and power is conveyed moreover, an electromagnetic wave -- this conductor -- a track is supplied
[0035] (Example 4) The plasma-treatment equipment of the example 4 of this invention is shown in view 9. this example differs from an example 1 in respect of using a permanent magnet for magnetic field formation etc. The permanent magnet 402 of surface flux density 1000Guss of a core is installed in the outside upper part of the cylinder-like vacuum housing 401 by the diameter of 30cm, and the thickness of 10cm. A permanent magnet 402 is movable in the vertical orientation which is the shaft orientations of a cylinder-like vacuum housing, and has the structure which can control the magnetic field distribution in a vacuum housing 401 by changing the position of a permanent magnet 402. A hole with a diameter of about 4cm is in the center section of a permanent magnet 402, and a 500MHz electromagnetic wave is introduced by the coaxial track 403 in a vacuum housing 401 through the hole. The air cored coil 404 is installed on the outskirts of an exterior side of a vacuum housing 401, and it has the structure which can control the magnetic field distribution formed with a permanent magnet 402 by the magnetic field by the air cored coil 404. A conductor is connected to the plate-like grounding electrode 405 outside a coaxial track 403, and, as for the coaxial cable 403 introduced in the vacuum housing 401, the core wire of a coaxial track 403 is connected to the plate-like grounding electrode 405

in near and the center section (feeding point) 412 of the radial stripline 406 arranged in parallel. Electromagnetic wave power is supplied to the other end of a coaxial track 403 through the waveguide 414 and the coaxial converter 413 from the electromagnetic wave wave motion VCO not to illustrate.

[0036] Drawing 10 shows the enlarged view of the radial stripline section in drawing 9 , and (a) and (b) show the plan seen from a sectional side elevation and the space lower part, respectively. As shown in drawing 10 , at this example, four striplines are arranged at the grade angle from the central point (feeding point) 412 at the radial. As for the radial stripline 406, the whole is covered with quartz glass 407.

[0037] It returns to drawing 9 , the sample base 409 is formed in a vacuum housing 401, and the sample temperature-control device 410 and the RF bias impression means 411 are installed in the sample base 409. Moreover, the processed sample 408 with a (diameter of 20cm) is laid on the sample base 409. The microwave supplied with the coaxial cable 403 emits an electromagnetic wave in the processed sample 408 orientation, spreading between the radial stripline 406 and the plate-like grounding electrode 405. a domain large [in a vacuum housing 401] by this -- crossing -- uniform electro magnetic radiation -- being possible -- becoming -- quantity -- uniform plasma formation is realizable

[0038] Next, an operation of the equipment of drawing 9 is explained. A electron cyclotron resonance magnetic field (since the electromagnetic wave used is 500MHz, they are about 178 Gausses) is formed near the upper part of the processed sample 408 in a vacuum housing 401 of a permanent magnet 402 and the air cored coil 404. The above-mentioned magnetic field is mainly formed with a permanent magnet 402, and the magnetic field by the air cored coil 404 has the auxiliary role on which the magnetic flux of the permanent magnet 402 which it is going to emit abruptly is converged. Therefore, the current which flows an air cored coil 404 is good at least. The electromagnetic wave supplied to the center section 412 of the radial stripline 406 through the coaxial cable 403 is spread, emitting an electromagnetic wave to space along with the element of each radial stripline. At this time, the length of each element of the radial stripline 406 can realize transmission and radiation of an electromagnetic wave efficiently by considering as the length of **20% of the integral multiples of the half-wave length of the electromagnetic wave to use. The material gas introduced by the interaction of the microwave and the aforementioned magnetic field which were emitted by the radial stripline 406 in the vacuum housing 401 is plasma-ized.

[0039] since radiation of an electromagnetic wave is performed by the radial stripline 406 -- the length of a stripline 406 -- a large -- uniform electro magnetic radiation can be performed also to an aperture vacuum housing, and a diameter quantity [of the macrostomia] uniform plasma can be realized When forming a plasma by this example, since the main magnetic field is formed with a permanent magnet, it can reduce the power consumption by the electromagnet which poses a problem with the conventional equipment. Moreover, since generation of a plasma also uses the diameter permanent magnet of the macrostomia, a electron cyclotron resonance can be made to start in the place near a processed sample position, and since microwave power is made to absorb further in the domain from electromagnetic wave induction to a electron cyclotron resonance position, sufficient ion and a sufficient radical density are realizable. The ion acceleration of the processed sample 408 can be carried out out of a plasma by impressing a RF bias by the RF bias impression means 411, and it can carry out incidence to the processed sample 408. the ununiformity in the processed sample side of the RF bias which poses a problem with the conventional equipment since a plasma touches the plate-like grounding electrode 405 installed in the position which meets a processed sample here -- cancelable -- quantity -- a uniform plasma treatment becomes possible

[0040] (Example 5) The configuration of the example 5 of this invention is shown in view 11 . Drawing 11 shows the plan of the microwave radiation section seen from the sectional side elevation and the space bottom section of plasma-treatment equipment. However, in drawing 11 , it is omitting for simplification of the RF electric-field impression device and chiller style to a processed sample. this example -- an example 4 -- receiving -- the near feeding point 512 of the radial stripline 506 -- it is -- the processed sample 508 side -- the shape of a disk -- a conductor 515 is installed, a central concentration of an electromagnetic wave is prevented, and the homogeneity of a plasma is raised Generally, the plasma formed is in the inclination that the circumference section becomes high-density [a center section] by the low density to the orientation of a path of a vacuum housing 501, for disappearance with a wall. for this reason, the electro magnetic radiation from a center section -- the shape of a disk -- equalization of a plasma is realized by suppressing by the conductor 515 Furthermore, by using a conductor 515 as a grounding electrode on this disk, it acts as a grounding electrode of the RF electric field impressed to a processed sample like the example of drawing 1 to the drawing 10 , and is enabled to give a reaction control function by forming the disk-like electrode 515 with materials, such as graphite, like an example given in drawing 10 from drawing 1 further.

[0041] (Example 6) The example 6 by this invention is shown in view 12 . To an example 4, this example installs the electromagnetic wave irradiation sections, such as the radial stripline 606 and the grounding electrode 605, out of a vacuum housing, and connects with a vacuum housing 601 through the quartz aperture 607. Since the electromagnetic wave feed zone (coaxial cable) 603 does not pass the vacuum septum section compared with the example of drawing 1 , it becomes easy to manufacture especially this example of a vacuum housing 601.

[0042] However, in this example, it has the disadvantageous point that a grounding electrode cannot be installed in the position which meets a sample 608. Moreover, this example can realize the electro-magnetic-radiation section similarly by dividing with a quartz aperture in the configuration of the example 1 of not only the example 4 of drawing 9 but the drawing 1 , the example 2 of drawing 5 , and the example 3 of drawing 7 .

[0043] (Example 7) The example 7 of this invention is shown in view 13 . this example conquers the disadvantageous fault of an example 6. the grounding potential which met the radial stripline 706 and carried out opening to the vacuum-housing 701 side from the quartz aperture 707 by 200% of the width of face of the width of face of the radial stripline 706 -- it is the structure which installed the conductor 715 the grounding potential which installed the electromagnetic wave in the vacuum-housing 701 side -- it emanates from the opening 716 of a conductor 715 The grounding electrode of the RF electric field which this impresses to a processed sample can be realized in the confrontation position of a processed sample. grounding potential -- the same

reaction control as the aforementioned example is attained by forming a conductor 715 with the quality of the materials, such as graphite the grounding potential installed in a vacuum-housing 701 side in this example -- although width of face of the opening 716 of a conductor 715 was made into 200% of the width of face of the radial stripline 706, it cannot be overemphasized that there is same effect also by the opening width of face of 100 to 500% of a domain

[0044] (Example 8) The example 8 of this invention is shown in view 14 . Drawing 14 is the side face cross section of equipment, and a plan (drawing as which the antenna section was regarded from the lower part) of the antenna section. this example is an application of an example 4 and it aims at raising the electro-magnetic-radiation luminous efficacy from each antenna arranged to the radial. The stripline constituted the three straight-lines-like antenna 806 from this example to the grounding potential electric conduction plate 805. In addition, although the antenna was made into three in this example, three or more odd are sufficient. If it is made into an intersection except the center section of an antenna when making a two or more straight-lines-like antenna cross and it is not odd, an electromagnetic wave cannot be supplied equally. This straight-line-like antenna 806 is covered with quartz glass 807. From the position used as the current of the electromagnetic wave on each antenna, and the wave node of a voltage distribution, the point shifted is made into an intersection and the aforementioned intersection is considered as the electric supply position 812 of an electromagnetic wave. Electrical transmission luminous efficacy of the electromagnetic wave between the tracks supplied to each antenna and an antenna with this electric supply position is made highly, and the efficient electromagnetic wave supply of it is attained.

[0045] (Example 9) In the plasma-treatment equipment in this invention, the manipulation example of an integrated circuit is shown in view 15 . It is process drawing of a self aryne contact manipulation in silicon-oxide etching, and drawing 15 (a) forms the polysilicon contest electrode 905 and the silicon nitride 903 on a silicon substrate 904, and is the example which processed the silicon oxide 902 which is an insulator layer further using the resist mask 901. Moreover, it is process drawing of a contact manipulation, and drawing 15 (b) forms a memory cell 905 on a silicon substrate 904, and is the example which processed the silicon oxide 902 which is an insulator layer further using the resist mask 901. A high working speed and manipulation selectivity are required in the structure of a high aspect [b / (b) / (a) and] in the dimension below 0.3 micron meter. Selectivity is an index which shows a silicon nitride or silicon, and the degree that does not process silicon in (b) by (a) to the silicon oxide which is a manipulation contrast. In order to obtain a high working speed with the conventional plasma-treatment equipment, when the plasma density was made high, it was difficult for the maceration of material gas to progress too much and to obtain high manipulation selectivity. However, also in a plasma density high in this invention, it enables a high working speed and high selectivity to be compatible by having impressed the RF electric field to the grounding electrode arranged in the position which a maceration is suppressed since electron temperature is low, and meets a wall, an electromagnetic wave introduction antenna, or a processed sample further, and having added the radical control function by the reaction on the front face of each part.

[0046] Although the example of this invention was explained above, this invention is not limited to the above-mentioned example. For example, although the surface flux density in a permanent magnet center section used the thing of 1000Gausses in the example, the permanent magnet used in the domain of 5000Gausses is chosen out of 200, and a required magnetic field distribution can be adjusted together with the path of the aforementioned permanent magnet.

[0047] Although the permanent magnet used the thing with a diameter [of 30cm], and a thickness of 10cm in the example 8 from the example 4, an effective magnetic field distribution can be formed by using the magnet with 10 to 100% of the thickness of 70 to 150% of the path of the diameter of a processed sample, an EQC, or the diameter of a processed sample, and the diameter of a processed sample. Such an ideal magnetic field distribution can be formed that especially the aperture of a permanent magnet is larger than the diameter of a sample and thickness's is still close to the above-mentioned aperture. Moreover, it is the same even if it forms the diameter permanent magnet of the macrostomia which could be densely located in a line, and magnetized not a single permanent magnet but the small magnet in the vertical orientation in equivalent. [two or more] When forming the diameter permanent magnet of the macrostomia which approached, has arranged the small magnet, and was magnetized in the vertical orientation in equivalent, it is making each small magnet into structure movable in the vertical orientation, and adjustment of the field interior division cloth of a magnetic field is attained. [two or more]

[0048] Although the example 7 showed the case where the number of radial striplines was four, from the example 3, even if it forms a stripline in an object and a radial by the element numbers from three to 20, it cannot be overemphasized that there is same effect. Moreover, the same configuration is possible, if it is odd, although the example 8 showed similarly the case where the number of radial striplines was three.

[0049] Although the operation gestalt 8 described from the gestalt 1 of operation at formation of a magnetic field only in the case of the combination of an air cored coil, an air cored coil, and a permanent magnet, also in which example, only an air cored coil is realizable with the configuration of the combination of an air cored coil and a permanent magnet, and either only of the permanent magnets.

[0050] Although the stripline has been arranged from the example 5 to the radial in the example 8, two or more straight-line-like striplines are arranged in parallel, and even if it supplies electric power to each stripline, there is same effect.

[0051]

[Effect of the Invention] The power consumption in the electromagnet in a electron cyclotron resonance type plasma generator is reduced sharply, and high-density ion and a high-density radical can be supplied to a sample. Moreover, a grounding electrode can be installed in the position which meets a processed sample, and equalization of a RF bias can be attained.

[0052] furthermore, the thing for which a plasma is formed by the electron cyclotron resonance by the electromagnetic wave of UHF band -- low gas ** -- a high-density plasma -- low -- the gaseous-phase status [****] can be realized and the activity grain kind which carries out incidence to a processed sample at the reaction on the plate-like front face of an electrode for electro magnetic radiation becomes controllable ** which satisfied simultaneously by this a demand called a high throughput, a high selection ratio, and a high aspect manipulation in the ultra-precision machining below 0.2 micrometer level, and was broken at

the long period of time -- a stable etching property can be acquired

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[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] Drawing showing the example 1 of this invention.
[Drawing 2] Explanatory drawing of the electro-magnetic-radiation section in an example 1.
[Drawing 3] The property view of UHF band electromagnetic wave and the electron cyclotron resonance plasma according to microwave conventionally.
[Drawing 4] Explanatory drawing at the time of forming a slit in the round conductor plate in an example 1.
[Drawing 5] Drawing showing the example 2 of this invention.
[Drawing 6] Explanatory drawing of the electro-magnetic-radiation section in an example 2.
[Drawing 7] Drawing showing the example 3 of this invention.
[Drawing 8] Explanatory drawing of the electro-magnetic-radiation section in an example 3.
[Drawing 9] Drawing showing the example 4 of this invention.
[Drawing 10] Explanatory drawing of the electro-magnetic-radiation section in an example 4.
[Drawing 11] Drawing showing the example 5 of this invention.
[Drawing 12] Drawing showing the example 6 of this invention.
[Drawing 13] Drawing showing the example 7 of this invention.
[Drawing 14] Drawing showing the example 8 of this invention.
[Drawing 15] Drawing showing the example 9 of this invention.
[Drawing 16] Drawing showing the relation between an electromagnetic wave frequency and the generation luminous efficacy of a plasma.
[Description of Notations]
101 [-- A coaxial track, 104 / -- The source of UHF electrification,] -- A vacuum housing, 102 -- An air cored coil, 103 the conductor of 105 -- grounding potential -- a plate, 106 -- dielectric, and 107 -- round conductor plate -- 108 [-- A processed sample,] -- A high pass filter, 109 -- A low pass filter, 110 111 [-- A temperature-control means, 114 / -- Temperature-control means,] -- A sample base, 112 -- A RF generator, 113 115 [-- A grounded plate, 118 / -- Capacitor,] -- A ring, 116 -- Gas introduction means 117 119 [-- A vacuum housing, 202 / -- Coaxial track,] -- The feeding point, 120 -- A slit, 201 203 -- electrical transmission way and 204 -- the conductor of the feeding point, the source of 205 --UHF electrification, and 206 -- grounding potential -- a plate -- 207 [-- A vacuum housing, 302 / -- Air cored coil,] -- A dielectric, 208 -- A round conductor plate, 301 303 -- the conductor of a coaxial track, the source of 304 --UHF electrification, and 305 -- grounding potential -- a plate -- 306 [-- Electro-magnetic-radiation antenna,] -- A dielectric, 307 -- A microstrip line, 308 309 [-- A permanent magnet, 403 / -- Coaxial track,] -- A round conductor plate, 401 -- A vacuum housing, 402 404 [-- Radial stripline,] -- An air cored coil, 405 -- A plate-like grounding electrode, 406 407 [-- A sample base 410 / -- Sample temperature-control device,] -- Quartz glass, 408 -- A processed sample, 409 411 [-- Coaxial waveguide converter,] -- A RF bias impression means, 412 -- A core, 413 414 [-- A permanent magnet, 503 / -- Coaxial track,] -- A waveguide, 501 -- A vacuum housing, 502 504 [-- Radial stripline,] -- An air cored coil, 505 -- A plate-like grounding electrode, 506 507 [-- A sample base 513 / -- Coaxial waveguide converter,] -- Quartz glass, 508 -- A processed sample, 509 514 [-- A vacuum housing, 602 / -- Permanent magnet,] -- A waveguide, 515 -- A disk-like electrode, 601 603 [-- Plate-like grounding electrode,] -- A coaxial track, 604 -- An air cored coil, 605 606 [-- A processed sample,] -- A radial stripline, 607 -- A quartz aperture, 608 609 [-- A waveguide, 701 / -- Vacuum housing,] -- A sample base, 613 -- A coaxial waveguide converter, 614 702 [-- An air cored coil, 705 / -- Plate-like grounding electrode,] -- A permanent magnet, 703 -- A coaxial track, 704 706 [-- A processed sample,] -- A radial stripline, 707 -- A quartz aperture, 708 709 -- sample base and 713 -- a coaxial waveguide converter, 714 -- waveguide, and 715 -- grounding potential -- a conductor -- 716 [-- Quartz glass, 812 / -- The feeding point, 901 / -- A resist mask, 902 / -- A silicon oxide, 903 / -- A silicon nitride, 904 / -- Silicon, 905 / -- Contest polysilicon, 906 / -- Memory cell.] -- Opening, 806 -- A straight-line-like antenna, 807

[Translation done.]